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V. ASTRONOMY.

THE CORONA OF THE SUN.

BY EPHRAIM MILLER, UNIVERSITY OF KANSAS, LAWRENCE.

A lecture delivered before the Academy at its annual meeting, at McPherson, December 29, 1899.

Prof. C. A. Young, perhaps the most competent authority upon solar phenomena, writing about the sun's corona, says: "We must evidently wait awhile for the solution of the problems presented by the beautiful phenomenon. Possibly the time may come when some new contrivance may enable us to see and study the corona in ordinary daylight, as we now do the prominences. The spectroscope, indeed, will not accomplish the purpose, since the rays and streamers of the corona give a continuous spectrum; but it would be rash to say that no means will ever be found for bringing out the structures around the sun which are hidden by the glare of our atmosphere. Unless something like this can be done, the progress of our knowledge must be very slow, for the corona is visible only about eight days in a century, in the aggregate, and then only over narrow stripes on the earth's surface, and but from one to five minutes at a time by any one observer."

Sir Robert S. Ball, in "The Story of the Sun," says: "Such is an outline of the facts known to us with regard to the corona; and it must be admitted that our information is at present of a somewhat meager description. We can only hope that the attempts to photograph the corona without having to wait for a total eclipse may ultimately prove successful.

"Doubtless many of our perplexities would vanish if a series of observations taken at brief intervals were certainly available. We might then expect to gain information regarding the changes in the corona, which it seems absolutely certain are in progress. We might expect, too, that some satisfactory evidence might be forthcoming as to the actual character of the material to which the coronal light is due."

In Langley's splendid book, "The New Astronomy," we read: "Outside all is the strange shape which represents the mysterious corona, seen by the naked eye in a total eclipse, but at all other times invisible even to telescope and spectroscope, and of whose true nature we are nearly ignorant from lack of opportunity to study it." On page 40, the same author says: "The sun went out as suddenly as a blown-out gas jet, and I became as suddenly aware that all around there had been growing into vision a kind of ghostly radiance, composed of separate pearly beams, looking distinct each from each, as though the black circle where the sun once was bristled with pale streamers, stretching far away from it in a sort of crown. This was the mysterious corona, only seen during the brief moments while the shadow is flying overhead."

The French astronomer, Flammarion, says, in his "Popular Astronomy": "What, then, is the corona? It is probably a region in which is found a variable quantity of detached particles, partially or wholly vaporized by the intense heat to which they are exposed. But how can these particles be supported in these burning heights? To this question we are already able to give three replies: (1) The matter of the corona may be in a state of permanent projection, being

composed of substances incessantly darted out by the sun and falling back on him. (2) The coronal substance may be more or less supported in the solar heights by the effect of a calorific or electrical repulsion. (3) Finally, the corona may be due to clouds of meteors, aerolites circulating around the sun in his immediate vicinity. All these explanations are perhaps in part true."

In Proctor and Ranyard's "Old and New Astronomy" we read as follows: "But it is evident on the one hand that no simple theory can be advanced in explanation of the phenomena of solar appendages manifestly complex and varied; and on the other, that the details of coronal structure and of coronal phenomena present problems far too difficult to be as yet solvable."

Miss Clerke, in her "History of Astronomy during the Nineteenth Century," says: "The corona is properly described as a solar appendage, and may be conjecturally defined as matter in a perpetual state of efflux from and influx to our great luminary, under the stress of electrical repulsion in one direction and of gravity in the other. Its constitution is of a composite character. It is partly made up of self-luminous gases, chiefly hydrogen, and the unknown substance giving the green ray, '1474,' partly of white-hot, solid or liquid particles, shining with continuous light, both reflected and original. The coronal materials must be of inconceivable tenuity, since comets cut their way through them without experiencing sensible retardation. Summing up what we have learned about the corona during some forty-five minutes of scrutiny in as many years, we may state, to begin with, that it is *not* a solar atmosphere. It does not gravitate upon the sun's surface and share his rotation, as our air gravitates upon and shares the rotation of the earth; and this for the simple reason that there is no visible growth of pressure downward in its gaseous constituents; whereas, under the sole influence of the sun's attractive power, their density should be multiplied many million times in the descent through a mere fraction of their actual depth."

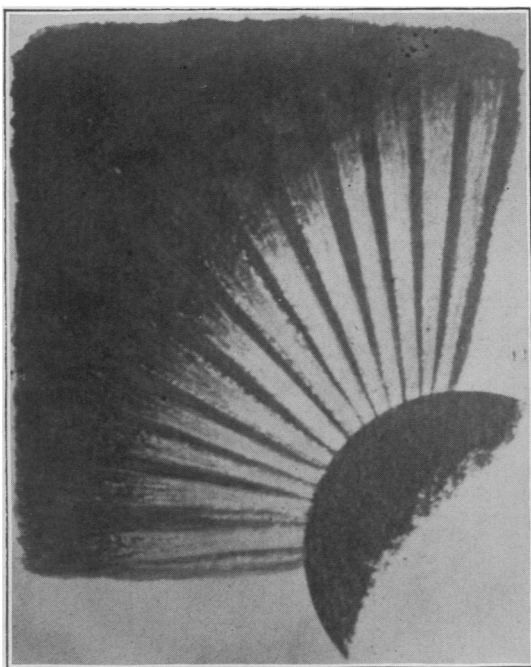
It is easily seen from the preceding extracts that the corona of the sun has been visible only on those rare occasions when solar eclipses are total; and the very short period of time during which a total eclipse lasts at any given point upon the earth's surface renders any examination of the corona a very difficult operation. Since the introduction of the camera and the spectroscope as adjuncts in all solar research, the amount of time and labor devoted to such work has been multiplied more than twofold. All the great observatories of the world are systematically engaged in trying to solve the mystery of the corona. Mountain peaks, clear skies and rare atmospheres have been sought for, and expensive trips to far-away lands have been undertaken, in order to determine once for all what this wonderful thing may be which persists in withholding from the inquisitive eye its secrets and its nature. Men have gone half way round the globe to witness for one, two, or six or seven minutes at most, the most beautiful object visible in the solar system. The question naturally arises, Is it possible, or will it *ever* be possible, for the human eye, with or without any kind of instrument, and at *any* time, to look upon and examine at leisure such a glorious appendage as that of the sun's corona? Will this nineteenth century, so full of splendid achievement in every field of scientific research, add to its other honors that of having made it possible, in the absence of a total eclipse, to see the corona? All efforts hitherto made have been without avail; have utterly failed.

In 1866 Mr. Lockyer, and in 1868 Janssen, made it possible for one to see at any time of day, when the sun is above the horizon and not obscured by clouds, the so-called "protuberances" or "prominences" that up to that time had been considered as mysterious as the corona is now. Miss Clerke says: "The eclipse

of 1868 is chiefly memorable for having taught astronomers to do without eclipses, so far, at least, as one particular branch of solar inquiry is concerned. Inspired by the beauty and brilliancy of the variously tinted prominence lines revealed to him by his spectroscope, Janssen exclaimed to those about him, '*Je verrai ces lignes-là en dehors des eclipses!*' On the following morning he carried into execution the plan which formed itself in his brain at the time of the eclipse."

More than a year ago an idea took possession of my brain that there must be some method by which the corona of the sun may be rendered visible at any time between sunrise and sunset, atmospheric conditions being favorable. In the latter part of April, 1899, I secured three strips of pine lumber, each about six or seven feet long, and of a uniform thickness of three-fourths of an inch. The strips were fastened to the outside of the tube of a Clark telescope of six inches object-glass, separated from each other by a distance of 120 degrees. Ordinary wrapping twine was used with which to make the strips secure and firm in their position. They were so placed that about three feet of each one was allowed to project beyond and in front of the object-glass. This done, a cardboard, sufficiently heavy, was cut into the form of a circular disk of seven inches diameter. Upon the inside of the circumference of the disk, and as close to the limb as possible, three small holes were pierced, through which pieces of fine flexible wire were put, and these were tied around the pine strips. By this arrangement the cardboard disk—an artificial moon—could be securely held in position, and by slipping the wires forward or backward, as might be necessary, the disk could be made to hide completely the entire face of the sun. It was expected and hoped that the effect would be the same as in the case of a true solar eclipse; that is, that the solar appendages would be revealed. All things being ready, the telescope mounted firmly upon the tripod, the pine strips fastened, and the cardboard moon put at a suitable distance from the object-glass, on the afternoon of May 3, 1899, the first trial was made; an observation was taken. The face of the sun being completely obscured, bright radiations were seen to issue from the limb of the artificial moon in great numbers. These radiations were carefully scrutinized, but it was soon made apparent that they were nothing but streaks of light, of a decidedly brassy appearance, reflected from the inside of the telescope, the barrel of which was made of brass. The cardboard moon was now shifted to a point a little farther away from the object-glass. The result was still the same—the brassy streaks, and all else. During all this time, and in spite of every effort to prevent it, the barrel of the telescope was flooded with light that poured into it from the surrounding atmosphere. Just here seemed to be the difficulty, the light came into the telescope apparently from everywhere, past the limb of the false moon.

For over an hour slight changes were made in the position of the false moon, at intervals of from five to six minutes each, at one time to a place nearer the object-glass, at another, to a point farther away; but all to no effect; the results were invariably the same, save that the brassy streamers were modified accordingly. Matters were becoming monotonous and rather disheartening, so much so that the question arose whether the observation should be prolonged or given up as a flat failure. The determination to succeed, or know the reason why success should not be attained, prolonged the work for some time longer. The time passed in shifting the false moon, readjusting the pine strips, keeping the telescope in proper position, straining the eye in order to see the sight, should a revelation be made; yet nothing was seen but the brassy reflections from the telescope itself, which seemed to be dancing and laughing as if in very mockery at every attempt to succeed. More than two hours had passed, and the goal to be



Observation of supposed corona of the sun without an eclipse.

reached was apparently as far off as ever. The observer was quite disheartened and discouraged, and about ready to give up in despair. In such a frame of mind, and quite willing to give it up as a bad job, suddenly and unexpectedly the false moon, for some reason or other, changed its position slightly, so that apparently its surface and the surface of the object-glass were no longer parallel to each other. Whether the lack of parallelism was a fact or not cannot now be determined. The effect produced was that the barrel of the telescope seemed to be completely filled with absolute darkness, the brassy streamers vanished, and along the upper right-hand limb of the false moon appeared, in all their beauty and soft light, the coronal streamers. There was no mistaking the vision. It was the genuine corona itself; a thing of beauty, and a glorious recompense for the time and labor that had been expended.

An attempt to change the position of the telescope so as to hold the sun in the field resulted in destroying the vision, and the coronal streamers disappeared from view. The following is a *facsimile* of a hand-made drawing of the corona, as seen on the afternoon of May 3, 1899. It is not a complete coronal form, for the reason that the cardboard disk extended beyond the limb of the sun, and prevented a view of the streamers other than as represented.

Several cardboard disks, one six inches in diameter, one seven and another eight inches in diameter were made, and used at varying distances. A great many obstacles had to be met and surmounted in preparing for the work, and great care had to be exercised in handling the apparatus. The telescope used was mounted on a tripod, and was exposed to the action of the wind. There was no driving-clock attachment; so that every movement had to be made by the observer, thus rendering the labor so much the more difficult. Other observations were taken in May and in June, but, on account of ill health, the observations had to be suspended during the summer, and there has been no opportunity since to resume them.

But that the corona of the sun was seen on the 3d of May, 1899, a day upon which there was no eclipse of the sun, either partial or total, can scarcely admit of doubt. There is a possibility that it may have been a vision of something else—an optical illusion, an “*ignis fatuus*,” or a dream.

At the moment when the picture was sketched, the “apparition” was situated in the vicinity of one of the poles of the sun, and not in the plane of the sun’s equator; and so clear and well defined was the shape, and so different from all other appearances, that the conclusion reached by the observer was that it was the corona itself. To be sure, he may have been mistaken, but he thinks not, and it is unfortunate that the observation of May 3 has not as yet been corroborated by other observations. The work will be resumed in the near future.

The difficulty in the case consists not in making an artificial moon, attaching it to a telescope, and locating it at a proper distance from the object-glass, but in flooding the barrel of the telescope with absolute darkness. When that is done, all other difficulties will seem but trifles and will vanish at once. The light of the sun that fills the surrounding atmosphere is the great foe to anything like success, and seems to bid defiance to every attempt. Shut out that light, exclude it entirely from the interior of the telescope by means of a conical hood that will extend some distance over the barrel of the telescope and forward as far, perhaps as the false moon, or further, and with the conveniences and appliances of a modern observatory, the result may be safely predicted—the corona will be made visible.

In conclusion, if the corona was seen upon the day mentioned, when there was no eclipse of the sun, as described in the foregoing, I think I am justified

in saying that the same thing can be done again and again, upon any clear day, during the hours of sunshine, no clouds interfering, and other atmospheric conditions being suitable, and the question as to the possibility of astronomers seeing and studying the greatest mystery of the sun at any time will be settled once for all.